Grinding and gouging
How moving ice can grind away rocks

Demonstrate how ice, a very soft substance, can grind rocks away by rubbing ice cubes over painted wood.

Ask the pupils:
- what will happen when they rub a clean ice cube on the piece of painted wood?
- what will happen when they rub a sand-covered ice cube on the piece of painted wood?

Carry out the activity by asking the pupils to rub a clean ice cube over the wood, pressing down as hard as possible. Next, ask them to press an ice cube on to some loose sand in a dish for about 15 seconds and then rub this over the wood. Are the results as predicted?

Photo: E. Devon

Ask the pupils:
- why are there scratch marks on the rock in the photo taken in Glacier National Park?
- how can the direction of the scratch marks be explained?
- The flooded U-shaped valley in the photo of Geiranger Fjord was carved by ice. How could this possibly have happened?

Glacial striations, Glacier National Park, Montana, USA

Courtesy US Geological Survey

View of Geiranger Fjord, Norway
Photo: Chris King

.....

The back up:

Title: Grinding and gouging

Subtitle: How moving ice can grind away rocks

Topic: This activity can be included in teaching the rock cycle; wearing away of rocks, erosion by ice

Age range of pupils: 10 - 14 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:
- explain that ice alone will not scratch rock;
- demonstrate that ice carrying sediment will scratch rock;
- realise that ice will scrape any soil and weathered, loose material from the surface of the underlying rock;
- work out the possible direction of ice movement;
- show that other evidence is needed to determine the actual direction of ice movement;
- explain how a valley glacier could erode a deep, U-shaped valley, given enough time.

Context:
- What happens when a clean ice cube is rubbed on a piece of painted wood? *Ice alone will not scratch the paint.*
- What happens when a sandy ice cube is rubbed on a piece of painted wood? *The paint will be scratched off fairly easily.*
- Why are there scratch marks on the rock in the photo? *Moving ice (a glacier) erodes material of all shapes and sizes from the valley floor as it moves downhill. The moving glacier acts rather like a bulldozer, stripping away anything that is loose above the underlying rock. Some of the eroded material becomes embedded in the bottom of the glacier and so scrapes along the newly-exposed rock beneath the ice and leaves behind line-shaped scratch marks, often called glacial striations.*
- How can the direction of the scratch marks be explained? *The direction of the scratch marks gives an indication of the trend of flow of the glacier (it could have flowed in either direction, in this photo, either up or down the picture). If you wanted to know which of the two directions it flowed in, you would need to look for other evidence, such as the general slope direction of the valley or the direction in which erratic boulders have been moved from their source.*
- How was the U-shaped valley in the photo carved by ice? *A valley glacier armoured with boulders and sand, carved this valley as it ground its way over the rock beneath. Since valley glaciers erode both the sides and base of the valleys they flow through, glacier-carved valleys have typical U-shapes, like the one in the photo. This one was later flooded by the sea to become a fjord. In contrast, river-eroded valleys have V-shapes (since most of the erosion takes place at the base of the 'V').*

Following up the activity:
Pupils could try using mixed sediment, sand and gravel, beneath their ice cube to scratch the paint. They can demonstrate that gravel will make deeper scratch marks than sand.
Pupils could also consider what would happen to the debris being carried by the ice when it melts. They can simulate this by freezing ice cubes of sandy/muddy water, then leaving them to melt and observing the results.

Underlying principles:
- Ice plus its load of rock debris causes erosion of rock surfaces by the process of abrasion.
- Ice occupies more volume than the same mass of water and is less dense than water. When ice is subjected to high levels of stress e.g. at the base of a glacier, the crystal lattice of the ice is partially disrupted, that is, the ice partially reverts to the liquid phase. There is thus a negative feedback system tending to reduce the effect of the applied stress. When the stress is reduced, ice is formed again so material from the ground becomes frozen into the base of the glacier. This process is known as regelation.
- In temperate glaciers, the mass of the glacier causes melting at the base which helps the glacier to move downhill so dragging its bedload over the ground, (polar glaciers are frozen to their bases).

Thinking skill development:
- Ice alone does not cause scratch marks - cognitive conflict.
- Explanation of thinking involves metacognition.
- Relating the scratch marks on the paint to glacial striations on rocks and to the formation of U-shaped valleys is bridging.

Resource list:
- clean ice cubes
- some pieces of painted wood, about 150 x 75mm
- sand in a dish
- photographs of glacial striations and a U-shaped valley
- ice cubes made from sandy/muddy water (for extension)

Useful links:
http://education.usgs.gov/schoolyard/glacialstriations.html
http://www.nsidc.org/glaciers/gallery/grooves.html
http://www.fettes.com/central%20park/Glacial%20striation.htm

Source:
Adapted from an idea by Peter Kennett, of the Earthlearningidea team, for Key Stage 3 National Strategy 'Strengthening teaching and learning of geological changes in KS3 science', 2004